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Children's Acquisition and Reversal Behavior in a Probability Learning Situation as a Function of Programed Instruction, Internal-External Control, and Schedules of Reinforcement[1]

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A three-choice, contingent task was used with 192 fifth and sixth graders in a $2 \times 2 \times 3$ factorial design combining instruction (programed instruction on selected probability concepts vs no programed instruction), locus of control (internal vs external), and schedules of reinforcement (33, 66, and 100%). The dependent measures were the percentage of correct acquisition responses, of correct reversal responses, and of pattern responses, as well as posttests on probability concepts. The major findings of the study were associated with schedule of reinforcement. In acquisition and reversal, *S*s under 100% reinforcement during acquisition tended to maximize the greatest, followed by the 66 and 33% conditions, in that order. The ordinal relationship among schedules was the exact reverse of the maximizing approach for the pattern responses. A partial reinforcement effect was obtained in reversal. Evidence indicated that programed instruction and locus of control affected maximizing behavior, patterning behavior, and resistance to extinction (though these variables did not interact with reinforcement schedule in the predicted direction). Finally the posttest data showed that instructed *S*s did learn more relative to noninstructed *S*s.

A series of investigations by Stevenson and Weir and their associates, beginning with Stevenson and Zigler (1958), have been concerned with the developmental study of probability learning and problem-solving behavior (summarized by Weir, 1964, 1967b). The basic paradigm employed was a three-choice contingent situation in which responses to one alternative were reinforced on a partial schedule, and responses to the other two

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alternatives were never reinforced. It has been consistently found that *S*s in the 7 to 13 year old age range do not maximize their responses (i.e., do not consistently choose the payoff button). Their typical response pattern involved some variant of a left, middle, right, or a right, middle, left scheme (Weir, 1964). Efforts to modify the patterning behavior in that age group have not been uniformly successful (Weir, 1967a, 1968).

Ojemann and his associates employed a more direct approach to the problem of eliciting maximizing behavior by devising a programed instruction booklet for selected probability concepts. They found that in a binary choice situation 8- and 10-yr-old instructed *S*s maximized their rewards significantly more than *S*s under no instruction (Ojemann, 1966; Ojemann, Maxey, & Snider, 1965a, 1965b, 1966).

Studies of schedules of reinforcement rather uniformly support the conclusion that a response that is partially reinforced during acquisition shows greater resistance to extinction than does a response that is continually reinforced (evidence summarized by Jenkins & Stanley, 1950; Lewis, 1960). Keller (1968) reviewed a variety of task conditions within the probability learning situation which resulted in the partial reinforcement effect (PRE), including written responses, motor responses, trial-by-trial predictions, state predictions, binary and tertiary problems, and contingent and noncontingent situations.

The construct "locus of control," and the related Children's Locus of Control Scale, was derived directly from Rotter's (1966) internal-external control of reinforcement construct (Bialer, 1960, 1961; Gozali & Bialer, 1968). Internal locus of control refers to the preception of positive and/or negative events as being consequential to one's own actions and thereby under personal control. External locus of control refers to the perception of positive and/or negative events as being unrelated to one's own behavior and therefore beyond personal control (i.e., perceived as being a result of luck, chance, fate, powerful others). The internal-external variable has been studied by means of *S* selection, task manipulation, or variation of instructions. A number of consistent results have been found: (1) the usual PRE under externally-controlled conditions, but the 100% group was most resistant to extinction under internally-controlled conditions (James & Rotter, 1958; Rotter, Liverant & Crowne, 1961); (2) externally-controlled *S*s under partial schedules were more resistant to extinction than the internal *S*s (Holden & Rotter, 1962); (3) in acquisition the increments and decrements in verbal expectancies following positive and negatively reinforcement, respectively, were significantly greater among internal *S*s than among external *S*s (James, 1957; Phares, 1957); and (4) external *S*s are associated more with unusual shifts in verbal expectancies, i.e., the negative recency effect or gambler's fallacy (Battle & Rotter, 1963; Phares, 1957).

The present study involved a $3 \times 2 \times 2$ factorial design combining schedules of reinforcement, exposure vs nonexposure to programed instruction, and internal-external control of reinforcement. The reinforcement schedules employed were 33, 66, and 100% thus enabling comparisons with Weir's (1964) data involving 33 and 66% schedules and also allowing an investigation of a PRE in reversal training. Instruction for one half the *S*s involved programed material on selected probability concepts; the others discussed with *E* arithmetic and probability concepts. On the basis of scores on the Children's Locus of Control Scale one half the *S*s were designated internally controlled *S*s and the others were externally controlled *S*s.

The major dependent variable was the *S*s' button pushing responses throughout 80 acquisition trials and 60 reversal trials, specifically, the percentage of correct acquisition responses, of correct reversal responses, and of pattern responses of the right, middle, left, or left, middle, right variety. (See Keller, 1968, for additional consideration of win-stay, lose-shift, win-shift, and lose-stay response strategies.) In addition scores on two written posttests were used to assess the specific effects of the instructional variables.

The following hypotheses were made:

(a) At terminal acquisition *S*s under 100% reinforcement will show the highest percentage correct response, followed by the 66% and 33% groups, in that order.

(b) Internally controlled *S*s will maximize to a greater degree on the partial schedules than external *S*s; in addition, externally controlled *S*s will show more unusual trial-to-trial fluctuations.

(c) Programed instruction will yield a greater tendency to maximize behavior than no instruction; further, the effect of instruction will be greater for external *S*s than for internal *S*s; programed instruction also will have a greater effect on *S*s under partial schedules than on those receiving 100% reinforcement.

(d) For internal *S*s there will be a reverse PRE (i.e., the 100% groups will be most resistant to change followed by the 66 and 33% groups, in that order) under both instructional conditions; while for external *S*s there will be the usual PRE under no instruction but a reverse PRE under instruction. (It should be noted that internal-external control studies used extinction, rather than reversal, procedures. This hypothesis assumes comparability of results across the two procedures for the response reinforced during acquisition. See Grosslight and Radlow (1956, 1957) for evidence from the animal literature supporting this assumption.)

(e) The response reinforced during reversal training will show a ter-

minal level for the three reinforcement groups similar to that found in acquisition (i.e., from highest to lowest, 100%, 66%, 33%).

METHOD

Subjects

Subjects were 192 fifth- and sixth-grade children from ten classes of two public elementary schools in Thomasville, Georgia. The *S*s ranged in age (on the day of the probability learning task) from 10 yr and 5 months to 13 yr and 11 months ($\bar{X} = 11$ yr and 7 months and $SD = 8\frac{3}{4}$ months) and in Otis IQ from 82–132 ($\bar{X} = 111.38$ and $SD = 10.38$).

A total *S* pool of 276 children was administered the Locus of Control Scale, and children whose scores were in either the top or bottom third of the range (96 from each approximate third) were selected for the study. One half of the internal *S*s and of the external *S*s were randomly assigned to the programed instruction condition and the others to the no instruction condition. Each of the resulting four groups were divided into three subgroups by random assignment of *S*s to the 33, 66, and 100% reinforcement conditions. Therefore, there were 12 groups of 16 *S*s each. Between groups the ratio of boys to girls, fifth to sixth graders, and blacks to whites was maintained as comparable as possible.

Two *E*s, one female and one male, conducted the study, each working with one half of all *S*s in each group.

Apparatus

The Children's Locus of Control Scale was administered as a paper-and-pencil test. Each child was provided with the instructions, the 23-item questionnaire, and an answer sheet on which to make responses (either yes or no). However, in order to control for differences in reading ability among *S*s, instructions and scale items were, in addition, delivered via tape recorder. See Bialer (1960, 1961), Gozali and Bialer (1968), and Keller (1968) for a copy of the scale and additional data on reliability, response bias, and correlations with social desirability measures.

Each *S* in the instruction condition was provided with a modified version of the programed instruction booklet entitled *Probability Thinking*, devised specifically for fifth graders (Ojemann, 1966; Ojemann *et al.*, 1966), a rule for covering the answers, and an answer sheet. The booklet is a linear program consisting of approximately 365 frames. In addition, three sets of materials for the student-performed demonstrations were available. One complete set of materials included the following: (1) Bag I containing six numbered ping-pong balls; (2) Bag II with six yellow and six orange marbles; (3) Bag III with nine yellow and three orange

marbles; (4) Bag IV containing four yellow and eight orange marbles; (5) Bag V with six yellow and three orange marbles; (6) One die and shaker; (7) A bowl and small cup, five rocks, five small toy animals, and Bag VI containing four yellow and four orange marbles, and some chips and bolts; (8) A pair of dice and shaker; (9) Bag VII with three blue and six orange marbles; (10) Play money (40 "dimes") and Bag VIII with eight orange and four blue marbles; (11) Bag IX containing three orange and seven blue marbles. This booklet dealt with the prediction of various binary events, of weather, of outcomes from rolling either a die or a pair of dice, and of outcomes in some day-to-day situations.

The apparatus for the three-choice, contingent situation was placed on a table between *E* and *S*. It consisted of a metal frame 21 in. wide by 16¼ in. high by 19¾ in. long. The side panels were constructed of sheet metal, while the top, bottom, front, and back were made of ¼ in. masonite. A handle on top allowed easy mobility, and the entire external surface of the apparatus was silver with the exception of the front panel (19 in. by 12¼ in.) facing *S*, which was yellow. Three identical response buttons—4½ in. apart—were centered on the yellow panel 5½ in. from the top. A white signal light was mounted on the midline 1½ in. from the top of the yellow panel. A metal spring (1 in. in diameter) extended through a hole in the front panel 3½ in. from the right side of the yellow panel and 1½ in. from the bottom, through which marbles (¼ in. ball bearings) were delivered. The marbles fell from the metal spring into an enclosed transparent tray 4⅞ in. by 2½ in. by 3½ in. A Foringer chimp pellet dispenser attached to one side of the inside of the apparatus dispensed the marbles and was controlled by three switches (each one wired to a corresponding response button on the front panel) on a removable *E*-control panel. A push button also on the control panel turned on the signal light, which was turned off by *S*'s response, and three lights inside the apparatus indicated to *E* the *S*'s response on each trial.

The Locus of Control Scale was administered in the children's respective classrooms. The instructional and probability learning segments of the study were conducted in small unused rooms.

Procedure

The Children's Locus of Control Scale was administered as a paper-and-pencil test to all children in each class, an entire class at a time. Instructions were given via tape recorder while *S*s read the directions to themselves. Then each scale item was read via tape recorder, while *S*s read each item to themselves, with time provided for responding immediately following each scale item. The scale was given to all classes by the male *E* within no more than 2 days.

During the instructional segment of the study, *S*s were seen in groups of eight which were homogeneous with respect to the internal-external variable. For the programed instruction condition instructions were in the booklet and read by *E*. After any questions *S*s proceed on their own. *E* remained in the room in order to keep *S*s working and to help with words or demonstrations when aid was requested. In general, the programed material required about six ½-hr sessions, 1 session per day on consecutive school days, for completion. At the beginning of each session *S*s were reminded to be certain to read carefully before responding, to cover the answers, to check their answers immediately, and to work at their own pace.

*S*s in the no instruction condition met with *E* for the same number of sessions. Meetings consisted of discussions based on material from Page (1959) and Razzell and Watts (1967). Some sections from Razzell and Watts were read and game-like situations (suggested in both sources) were also employed to maintain interest level. Discussions, readings, and games dealt with a broad, general concept of probability. None of the specific material from the booklet was employed or discussed.

*S*s were seen individually (in a single, ½-hr session) in the three-choice probability learning situation within 4 school days after completion of the instructional segment.

Each *S* was seated in front of the apparatus and told that he was going to play a game. His task was to push one of three buttons upon presentation of a signal light. He was told that a marble would be delivered for each correct response. *S*s were not allowed to handle or keep the marbles; but they were told that if they won enough marbles, they would win a prize of candy. All *S*s were instructed that the object of the game was to win as many marbles as possible. Each *S* was given a total of 140 consecutive trials, 80 acquisition and 60 reversal trials.

For each *S* one button was randomly selected as the correct one during acquisition and a different one during reversal. Across *S*s each button was designated the correct one an equal number of times. Marbles were delivered, according to the given schedule (either 33, 66, or 100% in acquisition, and 90% in reversal), contingent upon *S*'s pushing the correct button. Within a given phase (acquisition or reversal) the other two buttons never paid off. The partial reinforcement schedules in both the acquisition and reversal phases were prearranged and random; in acquisition the added requirement was made that no more than six reinforced or nonreinforced correct button pushes would occur in a row.

At the end of the 140 trials, each *S* was asked a series of questions designed to get a verbal report of their perception of the task, control in the task, and response strategy. *S*s were told how much candy they had won

(each S won some) but their candy was placed in the main office of the school with their names on it for them to pick up after school. All Ss were asked not to discuss the experiment with their classmates and friends in an attempt to control for the "grapevine effect."

When all Ss had completed all phases of the study the male E administered two posttests on probability concepts to all children in each class, an entire class at a time. The posttests were taken from Ojemann *et al.* (1965a, 1965b) and modified somewhat for group administration. The first posttest consisted of 25 questions, each one describing a situation involving two groups of colored objects and asking what color they would expect if E reached into a bag and pulled one out. The second posttest involved two parts, 12 questions each. The first part was similar to the first posttest, although squares and circles were involved. In the second part, Ss were asked to predict the next draw after one hypothetical draw was made without replacement.

RESULTS

An analysis of variance including four between-Ss factors (three schedules of reinforcement, exposure vs nonexposure to programed instruction, internal vs external control of reinforcement, and two Es) and one within-Ss factor (80 trials in acquisition and 60 trials in reversal) was used to analyze the data. (See Keller, 1968, for the analysis of variance tables.)

In all analyses with each response and in both acquisition and reversal the simple effect of E was nonsignificant. Although a small number of the E interactions were significant, they were uninterpretable and in each case accounted for less than 3% of the variance (Cohen, 1965, Eq. 2, p. 105). Therefore they will not be discussed further.

Schedule of Reinforcement Effects in Acquisition

It was hypothesized that Ss under 100% reinforcement would show the highest percentage correct response, followed by the 66 and 33% groups, in that order. The predicted order was obtained. Figure 1 shows that the rate of increase across trials was also greatest for the 100% groups, followed by the 66 and 33% groups. For the correct acquisition response the simple effects of schedule ($F(2,168) = 312.932$, $p < .001$) and trials ($F(79, 13{,}272) = 11.410$, $p < .001$) and a schedule by trials interaction effect ($F(158, 13{,}272) = 2.968$, $p < .01$) were highly significant.

As should be apparent from the above hypothesis, it was expected that the order of patterning responses would be the reverse of that found for the maximizing approach. The 33% groups yielded the highest percentage patterning responses, followed by the 66% and 100% conditions, in that

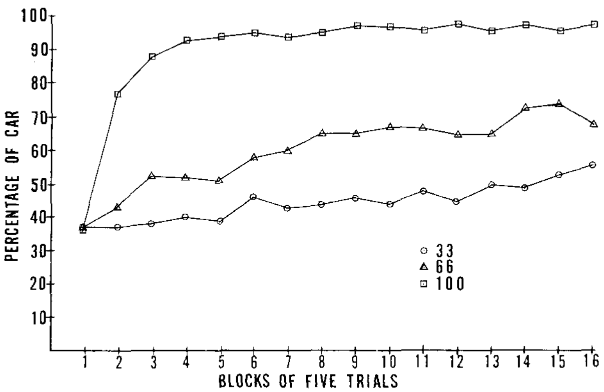

FIG. 1. Percentage of correct acquisition response (CAR) in acquisition as a function of schedule of reinforcement and trials.

order. For the patterning response the simple effects of schedule (F $(2{,}168) = 138.132$ $p < .001$) and trials ($F(79, 13{,}272) = 8.076$, $p < .001$) and a schedule by trials interaction effect ($F(158, 13{,}272$, $p < .01$) were highly significant.

Locus of Control Effects

It was hypothesized that internally controlled *S*s would maximize to a greater degree on the partial schedules than external *S*s, and, conversely, externally controlled *S*s would show more patterning responses. The predicted higher percentage of pattern responding among external *S*s was found only in the reversal phase. The locus of control by trials interaction was significant in both reversal ($F(59, 9912) = 2.061$, $p < .01$) and acquisition ($F(79, 13{,}272) = 1.28$, $p < .05$). However, in acquisition no clear relationship was observed in graphical representation of the interaction.

Instructional Effects

It was hypothesized that programed instruction would yield a greater tendency to maximize behavior than no instruction, that the effect of instruction would be greater for external *S*s than for internal *S*s, and finally that programed instruction would have a greater effect on *S*s under partial schedules than on those receiving 100% reinforcement. There was a significant interaction effect of instruction, locus of control, and trials in both acquisition ($F(79, 13{,}272) = 1.372$, $p < .05$) for the correct acquisition response and reversal ($F(59, 9912) = 1.334$, $p < .05$) for the patterning response. As predicted in acquisition, instruction had

a greater effect on the externally controlled *S*s than on the internal *S*s. That is, the instructed external *S*s maximized to a greater degree than external *S*s under no instruction (at least through the first 40 trials). There was little difference between the externally controlled *S*s under programed instruction and the internal *S*s under either instructional condition. No clear relationship was observed in graphical representation of the interaction in reversal, except that the internally controlled groups under instruction appeared to yield the lowest percentage of pattern responses throughout most of the reversal phase. The predicted simple effect of instruction and interaction effect of instruction and schedule were not found with any response in either phase. However, there was a significant instruction by trial interaction effect ($F(59, 9912) = 1.346$, $p < .05$) for the correct acquisition response in reversal. The no instruction condition resulted in more resistance to change than programed instruction.

Locus of Control, Instruction, and Schedule of Reinforcement Interaction Effect

It was predicted that for internal *S*s there would be a reverse PRE (i.e., the 100% groups would be most resistant to change followed by the 66 and 33% groups, in that order) under both instructional conditions; while for external *S*s there would be the usual PRE under no instruction but a reverse PRE under programed instruction. The hypothesized three-way interaction was not found. Examination of Fig. 2 indicates that schedule of reinforcement was the most important variable determining persistence in reversal in that the usual PRE was obtained

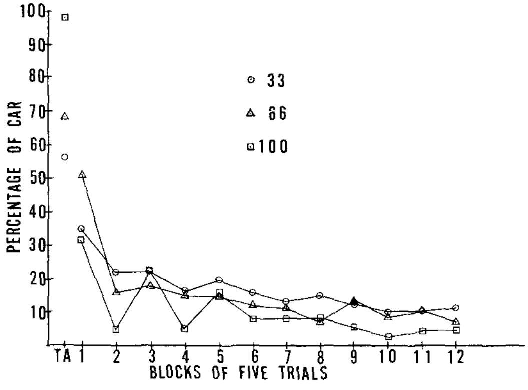

FIG. 2. Percentage of correct acquisition response (CAR) at terminal acquisition (TA) and in reversal as a function of schedule of reinforcement and trials.

with the correct acquisition response. That is, *S*s under 33% reinforcement were most resistant to change, followed by the 66 and 100% groups, in that order. There was a perfect crossover from terminal acquisition levels by the second trial block in reversal. This finding resulted in significant schedule ($F(2,168) = 8.492$, $p < .01$) and trial ($F(59, 9912) = 22.447$, $p < .001$) simple effects as well as a significant schedule by trial interaction effect ($F(118, 9912) = 3.064$, $p < .01$).

Schedule of Reinforcement Effect and Correct Reversal Response

Since the correct reversal response can be considered the complement of the correct acquisition response in reversal, it was hypothesized that the response reinforced during reversal training would show a terminal level for the three reinforcement groups similar to that found in acquisition (i.e., from highest to lowest, 100%, 66%, 33%). The predicted order was obtained. *S*s under 100% reinforcement gave up the old correct response and began responding to the new correct response at the fastest rate, relative to the 66 and 33% groups. Figure 3 shows that there was a perfect crossover from terminal acquisition level within two trial blocks. This result yielded significant schedule ($F(2,168) = 12.953$, $p < .01$) and trial ($F(118, 9912) = 26.235$, $p < .001$) simple effects and a schedule by trial interaction ($F(118, 9912) = 3.261$, $p < .01$).

The above hypothesized, and obtained, ordinal relationship among the reinforcement groups suggests the reverse order for the pattern response. The expected ordinal relationship was found—i.e., from highest to lowest percentage pattern response, 33%, 66%, 100% groups. The simple effects of schedule ($F(2,168) = 9.213$, $p < .01$) and trials ($F(59, 9912) = 10.721$,

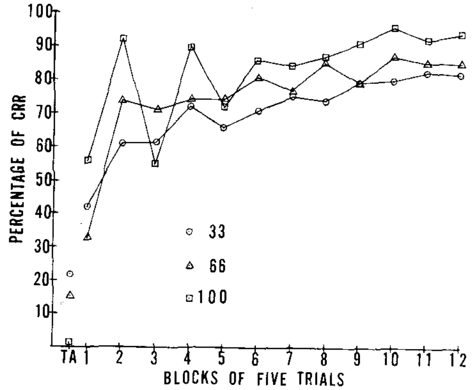

FIG. 3. Percentage of correct reversal response (CRR) at terminal acquisition (TA) and in reversal as a function of schedule of reinforcement and trials.

$p < .001$) were significant, as was the interaction between schedule and trials ($F(118, 9912) = 3.272$, $p < .01$).

Posttest Scores

Posttest scores were not available for all *S*s due to absences on the day of posttest administration. Therefore, *S*s were randomly selected for each group so that there were 12 *S*s per group (6 *S*s per *E*). The resulting analyses were 2 (instruction) by 2 (control) by 3 (schedule) by 2 (*E*) analyses of variance for each posttest.

Programed instruction did result in better posttest performances. On Posttest 1 there were significant instruction ($F(1,120) = 34.739$, $p < .001$) and schedule ($F(2,120) = 5.526$, $p < .01$) simple effects. The obtained means for instruction were programed instruction = 21.38 and no instruction = 17.54. The means for schedule of reinforcement conditions were as follows: 100% = 20.75, 66% = 19.52, and 33% = 18.10. The instruction simple effect was the only significant finding on Posttest 2 ($F(1, 120) = 24.643$, $p < .001$). The obtained means were instruction = 20.09 and no instruction = 16.83.

A one-way analysis of variance was employed to examine the differences on the posttests among programed instruction, no instruction, and children who did not participate in the main study but took only the posttests. For each posttest analysis, 72 *S*s were randomly selected for each condition (instruction, no instruction, and control). Differences among groups were significant for both posttests. The means on Posttest 1 were as follows: 19.50, 16.42, and 18.46 for the instruction, no instruction, and control conditions, respectively. On Posttest 2 the means for the corresponding conditions were 20.10, 16.83, and 15.31, respectively.

Finally, computation of the correlation between Locus of Control Scale scores and IQ scores was also made, resulting in a correlation of .477 ($n = 177$, $p < .01$).

DISCUSSION

The major results obtained in the present study were associated with schedule of reinforcement. In both acquisition and reversal the simple effect of reinforcement schedule and its interaction with trials were highly significant for every response measure. As hypothesized for acquisition, *S*s under 100% reinforcement showed the greatest tendency toward correct response maximization, followed by those under 66 and 33% reinforcement, in that order. The obtained levels of responding were approximately the same as those reported by Weir (1964) for comparable schedules of reinforcement.

In reversal a PRE was obtained, in agreement with a large number of

studies with a variety of organisms and situations (reviewed by Jenkins & Stanley, 1950; Lewis, 1960). That is, when the rewarded button was switched at the beginning of the reversal phase, *S*s under 33% reinforcement persisted longest in pushing the old correct response, followed by the 66 and 100% groups, in that order. This finding was contrary to the hypothesized three-way interaction effect of locus of control, instruction, and reinforcement schedule.

For the patterning responses the ordinal relationship among schedules was the exact reverse of the maximizing approach in both acquisition and extinction. When the counting procedures for the pattern response are equated, the obtained percentages closely approximate those reported by Weir (1964).

With few exceptions the predicted effects of instruction and locus of control were not significant. In acquisition, as hypothesized, the effect of instruction was greater for external *S*s than for internal *S*s. Specifically, externally controlled *S*s under programed instruction maximized to a greater degree than external *S*s under no instruction, while there was no difference between the external *S*s under programed instruction and the internal *S*s under either instructional condition. It was expected that programed instruction would produce behavior similar to that of internally controlled *S*s. Therefore, the obtained interaction is consistent with the findings of other investigators that skill-oriented instructions (Hyman & Jenkins, 1956; James, 1957; Phares, 1957; Slovin, Schumer, & Myers, 1965) and internally controlled *S*s (James, 1957) yielded greater maximization than chance conditions or externally controlled *S*s.

In reversal *S*s under no instruction showed greater response persistence to the old correct button than *S*s under programed instruction. Following the same theoretical framework as in the previous paragraphs, this result is consistent with the findings of Holden and Rotter (1962). They found that chance instructions led to significantly more trials to extinction than skill instructions.

Further, as hypothesized external *S*s produced a higher percentage of pattern responding than internal *S*s, though only in the reversal phase. This finding is consistent with studies employing chance- and skill-orienting instruction (James, 1957; Phares, 1957), chance and skill tasks (Goodnow, 1955), and externally and internally controlled *S*s (Battle & Rotter, 1963; James, 1957).

Therefore, there does appear to be some evidence that programed instruction and locus of control affect maximizing behavior, patterning behavior, and resistance to extinction (though these variables did not interact with reinforcement schedule in the predicted direction) in the probability learning situation employed in the present study.

It appeared evident from the postexperimental interview that *S*s perceived the task as one controlled by chance. By definition such a perception would be one of external control, and the resulting prediction would be a PRE in reversal. It is suggested that future research on the internal-external construct employ situational manipulations (either instead of, or along with, an internal-external scale) to insure, for a given experimental group, a more uniform perception of the task.

The programed material employed in the present study, which did improve children's performance on a binary choice task (Ojemann *et al.*, 1956a, 1966), did not influence (as much as expected) children's behavior in a three-choice, probability learning situation. That is, there was little positive transfer, for *S*s in this study, from instructional material dealing primarily with binary situations to a tertiary task. This is despite the fact that on written posttests *S*s under programed instruction scored higher than those under no instruction and other children who did not participate in any phase of the study.

A final result in the present study was the significant positive correlation between Locus of Control Scale scores and IQ scores. The higher the score on the internal end of the dimension, the higher the IQ. Crandall, Katkovsky, and Preston (1962) have reported significant correlations between the Intellectual Achievement Responsibility Questionnaire (a test designed to assess children's perception of internal-external control in intellectual, achievement related situations) and IQ for boys, but not for girls. Bialer (1961) reported a positive correlation between Locus of Control scores and MA based on PPVT scores.

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